SECTION 25 5000

INTEGRATED AUTOMATED FACILITY CONTROLS

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LANL MASTER SPECIFICATION

When editing to suit project, author shall add job-specific requirements and delete only those portions that in no way apply to the activity (e.g., a component that does not apply). To seek a variance from applicable requirements, contact the ESM I&C POC.

When assembling a specification package, include applicable specifications from all Divisions, especially Division 1, General Requirements.

Delete information within “stars” during editing.

Specification developed for ML-3 projects. For ML-1 / ML-2, additional requirements and QA reviews are required.

TA-53 LANSCE is not required to use the BACnet provisions of this Section because they have standardized on a different protocol.

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PART 1 GENERAL

1.1 SECTION INCLUDES

A. This section includes the specification for development of the Building Automation System (BAS). The BAS system architecture utilizes intelligent distributed control modules, located throughout the building, that communicate over a BACnet™ controller network and whose controlling software resides on a central server connected to the campus Ethernet® LAN (Primary LAN).

B. It is the intent of this section to provide, install, connect, program, and calibrate the additions and/or modifications to the BAS as necessary to provide fully automatic control for all systems as shown in the control drawings, stated in the sequences of operation. Some equipment controls are specified in other portions of the contract documents. As work of this section, coordinate with these other suppliers and trades to provide a complete BAS.

C. It is the responsibility of the bidder to read and conform to all sections of the specifications, review all contract drawings of all divisions, and coordinate with all equipment suppliers of material specified under other sections of the specifications.

D. The engineering, installation supervision, programming, graphic development, calibration, start up, and checkout necessary for a complete and fully operational BAS, as specified hereafter, shall be provided under this section.

E. Provide training and instruction of the installed BAS.

F. Provide the necessary materials and manpower to participate in the testing, adjusting, and balance and the commissioning process as required by those sections of the specification.

1.2 RELATED SECTIONS

A. Section 28 3100 – Fire Detection and Alarm

B. Section 22 0554 – Identification for Plumbing, HVAC, and Fire piping and Equipment

C. Section 23 0800 – Commissioning of HVAC

D. Section 26 0533 – Raceway and Boxes for Electrical Systems

E. Section 26 0519 – Low Voltage Electrical Power Conductors and Cables

F. Section 26 0553 – Identification for Electrical systems

G. Section 26 0800 - Commissioning of Electrical Systems[Future]

1.3 SUBMITTALS

A. Submit the following in accordance with the requirements of Section 01 3300, Submittal Procedures:

1. With Bid: BAS system manufacturer and contract information for local installing contractor and factory representative. Failure to comply with the specified requirements of this section will result in rejection of submittal.

2. Submittals shall consist of shop drawings, catalog data sheets, graphic displays, and software development parameters as defined in the following paragraphs. No materials shall be purchased and no work shall be conducted at the job site until submittals have been reviewed and approved.

a. Shop drawings shall be provided that show detailed communications architectures (including connection to the LANL campus LAN), control devices, electrical ladder diagrams, control system schematics, approved protocol implementation compliance statements (PICS), sequences of operation, and a material list. These same sequences of operation shall also be provided as a separate document from the drawings in either Microsoft Word or PDF format. All systems and the associated control components as well as all connections between components shall be clearly indicated. The submittal shall indicate the required coordination with equipment supplied by sources other than this section. The intention is for the shop drawings to be comprehensive enough for the installation crew to complete all aspects of the installation without the need for supporting documentation, except third party equipment installation manuals. All wiring shown on the drawings shall be labeled on both ends and these labels shall be used in the installation process for ease of comparing the shop drawings to the actual field installation. Each control

component shall be given a unique identifier. This identifier shall be used in creating equipment field device labels and in the sequence of operation so that each device can be matched uniquely to the drawings.

i. Electrical Ladder Diagrams shall be shown on the shop drawings. Electrical ladder diagrams shall show the specific details of all switches, relays, motor starters, etc. The electrical ladder diagrams shall show the correct control wiring and interlock wiring of all equipment provided under the Contract. Each diagram shall reference the correct power source by breaker panel and circuit number.

ii. The sequence of operation for each controlled system shall be provided with reference to the control device identifier. The sequence of operation shall break down the control operation by major function (e.g., mixed air control, occupied-unoccupied, smoke purge, etc.) and describe in detail the correct operation and interaction with other system functions. Use of the sequences of operation stated on the contract control drawings is acceptable; however, they shall be modified to reflect actual control device identifiers. Point list tables shall be included to describe alarm, monitoring, interlock, and other general functions.

iii. A complete material listing shall be included on the shop drawings that show the device model numbers, control device identifiers, quantities, manufacturers, etc., of all equipment provided under this section. The material list shall be organized in alphabetical order so that it can be easily compared to the associated catalog data sheets.

b. Catalog data sheets shall be provided for each different piece of equipment provided under this section. At a minimum the data sheet shall contain sufficient information so that compliance with the specification can be verified. Where multiple models or options are indicated on the same catalog data sheet, the equipment proposed shall be circled or otherwise indicated (highlighter is not acceptable because of copy quality). The catalog data sheets shall be organized in alphabetical order to match the material listing on the shop drawings.

c. Point verification and sensor calibration forms shall be submitted for all points and sensors that are installed as part of the BAS. This includes all points connected to unitary controllers (UCs). Once approved, the Contractor shall complete the forms during startup to document successful point functionality and sensor calibration. The completed forms shall be included as part of the record documentation. The LANL Construction Inspector reserves the right to designate a representative to monitor completion of the point verification.

d. All graphic slides (or typical graphics for identical equipment) proposed for use on this project shall be submitted for review and approval. The submitted slides shall be printed in color or submitted electronically as a PDF or other commonly viewable format. All real-time display fields, user picks, set point picks, etc. shall be clearly indicated. No graphic software

shall be installed on the job site until the graphic slides have been approved.

e. Software development parameters including all trend logs, reports, point alarm parameters, passwords, and scheduling shall be submitted based on the contents of this specification section. The information contained in this portion of the submittal shall be followed during development of the programming code and shall be used for evaluation of the systems performance during the commissioning phase.

i. Report templates shall indicate what information will be presented on each report, how the information will be presented, report hard disk upload parameters, and report log file names.

ii. Blank forms shall be submitted for completion of password information by the LANL Construction Inspector. The forms shall allow the LANL Construction Inspector to fill in the operators name and approved password level. During LANL personnel training, the BAS programmers shall coordinate with the approved operators to input the correct passwords and password levels.

iii. Blank schedule forms for each air-handling unit shall be submitted for completion by the LANL Construction Inspector. Additionally, a blank schedule group form template shall be submitted so the LANL Construction Inspector can identify schedule groups of HVAC equipment.

f. Provide detailed operation sequences for all variable frequency drives including required ramp up/down speeds, accelerations, resets, and deadbands.

1.4 QUALITY ASSURANCE

A. Qualification of the Installing Firm: The installing firm shall:

1. Have satisfactorily installed at least five (5) BAS systems of equivalent nature and scope to the system described in this Section.

2. BAS supplier shall have an authorized factory representative and service department of the product manufacturer within 125 miles of LANL.

3. Provide the services of a qualified system technician to design the system and to test the completed system.

4. Be a factory-certified representative of the manufacturer of the system that will be used on this project.

B. Acceptable Building Automation System Installers:

1. The following Factory Authorized Installers have demonstrated their capabilities to provide a BAS meeting LANL standards and the criteria herein (no substitutions).

a. Integrated Control Systems, Inc. [Automated Logic]

b. Automated Control Systems, Inc. [Alerton Technologies]

C. Qualifications of the BAS system technician: The BAS system technician shall:

1. Be factory trained in the theory, operation, installation, and troubleshooting of the BAS that will be used for this project.

2. Have satisfactorily designed at least five (5) BAS systems of equivalent nature and scope to the system described in this Section.

3. Have satisfactorily field-tested at least five (5) BAS systems of equivalent nature and scope to the system described in this Section.

1.5 RECORD DRAWINGS

A. Record drawings shall be provided as required by the general contract requirements. Record drawings shall not be completed until after installation is complete. Any changes made during installation shall be recorded as red-lines on the approved coordinated BAS shop drawings as they are made. These red-line drawings shall be available at all times for inspection by the LANL Construction Inspector. At completion of the project, all hand drawn field changes shall be incorporated into a clean reproducible set of as-built drawings. These as-built drawings shall be provided to LANL electronically (current AutoCAD format) and used during the training sessions.

B. The Contractor shall furnish complete spare parts lists, operating instructions, maintenance literature, and completed point verification and sensor calibration forms.

C. Two (2) sets of the following documents shall be delivered to the LANL Construction Inspector prior to the beginning of training:

1. One operating manual for each component purchased through a third-party vendor including equipment such as computers, printers, video monitors, interface cards, modems, etc.

2. All manuals relating to operating system software. This requirement includes not only the BAS operating software but also Windows 2000®, etc.

3. A systems programmer's manual that includes all information necessary to perform BAS programming and produce system graphics.

D. After final occupancy and all debugging have occurred, the Contractor shall prepare two copies of all project-specific control software on non-volatile computer recording media (CD) and deliver them to the LANL Construction Inspector.

E. License agreements for all supplied software shall be provided.

F. Licensed copies of all specialty software needed for controlled configuration.

1.6 SYSTEM TESTING

A. At the termination of the point verification and sensor calibration process, the contractor shall submit completed and approved point verification and calibration forms for each point or sensor in the system.

B. Upon successful completion of all point verification and sensor calibration testing, the Contractor shall submit hard copies of all trend logs as specified in PART 3 of this section. The trend logs shall trend at least 48 hours of normal uninterrupted operation (non-weekend or holiday) for the purpose of documenting proper implementation of the control sequences of operation. The control sequence of operation shall also be verified by the completion of a Sequence of Operation (SOO) commissioning checkout form in accordance with the example supplied by LANL FWO-DECS.

C. The LANL Construction Inspector reserves the right to participate in or assign a representative to participate in the startup, testing, programming, or any other aspect of the construction of this project at no additional cost to LANL. In general, the FPT shall be observed by a member of the FWO-DECS I&C Team who will deliver a punch-list delineating the deficiencies found in the BAS.

D. The Contractor shall be responsible for developing and implementing a Pre-Operational Acceptance Test (POAT) before Functional Performance Testing (FPT) begins. This test shall verify the point-to-point wiring, calibration, field device operation, and basic functionality of the BAS. The Contractor is responsible for back-checking and documenting his own work before a system or portion of a system is observed for FPT.

E. The contractor shall perform and otherwise support the FPT provided by the commissioning agent. See Section 23 0800, Commissioning of HVAC for details.

1.7 TRAINING

A. Provide a total of 80 hours of training time.

B. During the initial startup phase of the project, the BAS supplier shall permit the LANL operating personnel to be involved with the troubleshooting, initial startup, point verification testing, performance trending and sequence of operations verification.

C. Prior to the final system trending, provide three days (20 hours) of training for up to six (6) LANL Construction Inspector-designated operating personnel, at least one of which shall be from LANL FWO-DECS/ I&C, or their designee. The training shall cover all general aspects of the BAS system installation, wiring, calibration techniques, programming, troubleshooting, etc. The training shall not cover the details of this specific project. The training shall provide the same structure and depth as that provided to a factory authorized representative's installation and programming personnel.

D. Upon completion and acceptance of the work, provide three days (20 hours) of training for up to six (6) LANL Construction Inspector-designated operating personnel who have responsibility for the mechanical/control system. This training shall be conducted on site and shall focus on the specifics of this project. A complete training booklet shall be provided and used during the training period. The booklet shall include the as-built drawings and the sequence of operations.

E. The BAS supplier shall provide 40 additional hours of onsite training during the warranty period. The Contractor shall provide this training at the request of the LANL Construction Inspectors. The LANL Construction Inspectors will give at least one-week notice of the need for additional training. Warranty and service time shall not constitute training hours.

1.8 SERVICE AND WARRANTY

A. The system supplier shall have a maintenance support facility complete with system technicians, diagnostic and test equipment, and new spare components. Emergency service shall be available in the local office on a 24-hour, 7-day-a-week basis. The service agent shall provide a continuously monitored local service telephone number for emergency service.

B. Service and maintenance shall be provided for one (1) year from time of substantial completion or from successful completion of the SOO functional testing, whichever is later. If the manufacture has a standard warranty that exceeds the specified requirement then the longer manufacturers warranty shall be provided to the LANL Construction Inspector. Service during this period shall be available within 12 hours from the time the trouble call is placed. Warranty shall be for all materials and labor provided as the scope of work of this Section.

PART 2 PRODUCTS

2.1 PRODUCT OPTIONS AND SUBSTITUTIONS

A. Comply with Section 01 2500, Substitution Procedures.

2.2 SYSTEM FUNCTIONALITY

A. AHU's

1. All AHUs with economizer sections must be equipped with (as a minimum):
    a. OA, RA, and SA sensors.
    b. OA flow measurement and minimum OA control.
    c. Indication of damper and valve position.
2. All VAV boxes must be equipped with (as a minimum):
    a. Supply air temperature to zone, zone temperature, and zone CFM.
    b. Indication of damper and valve position.

3. Space temperature sensors shall have setpoint adjustment that is limited to ± 2ºF.

2.3 NETWORKING / COMMUNICATIONS

A. Primary Local Area Network (LAN).

1. Provide a connection to the primary ETHERNET® LAN communication network.

2. The only BAS equipment connections to the Primary LAN are the BAS Gateways or Web Interfaces. IP addresses for these devices shall be assigned by LANL CCN-5 in coordination with LANL FWO-DECS. All other BAS hardware shall reside on either the Controller LAN or the Sub-Controller LAN.

3. All BAS devices that reside on the Primary LAN shall communicate in BACnet™ encoded to be compatible with the ETHERNET® and shall connect to an existing LANL BAS server running a single copy of the controlling software. BAS devices that communicate using proprietary protocols or LonTalk protocols are unacceptable.

B. Controller Local Area Network (LAN).

1. All BAS Primary Controllers, Application Specific Controllers, and Unitary Controller Interfaces within a specific building shall reside on the second tier LAN referred to as the Controller LAN. The Controller LAN shall begin at the building BAS Gateway and extend to one or more BAS Controller LAN controllers located throughout the building.

2. Development of the Controller LAN is work provided entirely under this section of the specification.

3. All BAS Devices that reside on the Controller LAN shall communicate in BACnet™. Proprietary or LonTalk protocols shall not be permitted except for VFDs that may be connected using a LonTalk or Modbus™ network.

C. Sub-Controller Local Area Network.

1. All lower-level controllers associated with each Unitary Interface Controller shall reside on the third-tier LAN referred to as the Sub-Controller LAN.

2. Unitary Controllers (UCs) shall be installed on a Sub-Controller LAN. These LAN's shall operate off the associated Unitary Controller Interface but in no case shall the Sub-Controller LAN be necessary for standalone operation of any attached UC.

3. All BAS Devices that reside on the Sub-Controller LAN shall communicate in BACnet™. Proprietary or LonTalk protocols shall not be permitted except for VFDs that may be connected using a LonTalk or Modbus™ network.

4. The Sub-Controller LAN shall operate using RS-485 at a selectable speed of from 9.6K to 115.2K baud. Development of the Sub-Controller LAN is work provided entirely under this section of the specification.

2.4 BACNET™ COMPLIANCE

A. The BAS system shall utilize BACnet™ communications between all controllers on the controller LAN as defined by ANSI/ASHRAE Standard 135-2001. This means that the system shall use BACnet™ as the communication protocol between distributed controllers communicating on the Controller LAN and that proprietary or LonWorks protocols are not acceptable except for communication with VFDs. The BACnet™ communication protocol shall, at a minimum, support the following Objects and Application Services (Conformance Class 3):

Objects >	Binary Input	Services >	Read property
	Binary Output		Write property
	Binary Value		I-Am
	Analog Input		I-Have
	Analog Output		Read Multiple Property
	Analog Value		Write Multiple Property
	Calendar		Who-Has
	Schedules		Who-Is

B. The communication network between controllers (Controller LAN) shall be EIA-485, at least 78.4kbps, using either MS/TP or 156K baud using ARCNET® at the Data Link Layer or shall be ETHERNET®. Systems that use proprietary protocol for the main controller field bus are not acceptable.

2.5 CENTRAL BAS WORKSTATION SERVER

A. The LANL BAS Workstation server and as appropriate, web appliance, for this project shall be installed in coordination with LANL FWO-DECS I&C Team. The operating system on these servers shall be Windows 2000 Server (or better), and are maintained by LANL FWO IIM. The operating system on web appliances, if different from Windows 2000 Server, shall be maintained by the controls vendor in cooperation with FWO-DECS I&C Team. The BAS control software on these servers is maintained by LANL FWO-DECS. All necessary software or server/appliance upgrades and database consolidation required for this new project to integrate with other existing projects from this same controls vendor shall be provided by the Controls Contractor. The intent here is to utilize the existing central servers/appliances and integrating the new building databases on the server/appliance whenever possible.

B. If the capacity of the existing LANL BAS server or appliance for this vendor would be exceeded by the addition of this new project, provide one new rack mountable server. This server shall be consistent with current LANL FWO-IIM server specifications, including all necessary hardware and software requirements described by the LANL FWO-IIM OCSR and as indicated on the Contract Drawings and as required for a fully functional system. New servers shall be submitted to security scanning (CPAT) performed by LANL CCN-5 before installation. New appliances shall also be rack mountable if such a version exists.

C. Web Based Graphical User Interface Software (GUI)

1. The Graphical User Interface (GUI) shall be a comprehensive software package, a 32-bit application completely compatible with the LANL BAS server Operating system if it resides on the server, or shall reside separately on a vendor-supplied web appliance. GUI's that use a modified Windows Operating System (OS) are not acceptable.

2. The GUI shall be installed on the appropriate LANL BAS server or web appliance and available on the LANL intranet (Primary LAN) using a standard web browser compliant with current LANL IA-CA01 or W3C standards. The web interface GUI shall have monitor and control, setpoint change, and scheduling capability to all points of the BAS system. Access to these functions shall be controlled by password level, defined later in this section. Engineering functions (graphics generation and programming) are not available through the GUI and are described in following sections.

3. The GUI shall make extensive use of color to communicate information and shall graphically display in 1024 by 768 pixels 24-bit True Color.

4. The GUI software shall minimize operator training through the use of English language prompting, English language point identification, and industry standard PC application software.

5. The operator interface shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device, and "point and click" approach to menu selection. The users shall be able to start and stop equipment, change schedules, change setpoints, and create/view trends from graphic displays through the use of a mouse.

6. At the option of the user, the GUI shall provide consistent graphical or text-based displays of all system points and application data described in this specification. Point identification, engineering units, status indication, and application naming conventions shall be the same at all operator devices.

7. User-definable, automatic log-off timers of from 1 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.

D. Password protection:

1. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, programming access, display and data base manipulation capabilities as deemed appropriate for each user, based upon an assigned password. A minimum of five (5) levels of access shall be supported and a minimum of 50 passwords shall be supported.

2. Operators shall be able to perform only those commands available for their respective passwords. Menu selections displayed at any operator device, including portable or panel mounted devices (future), shall be limited to only those items defined for the access level of the password used to log-on.

E. System Interaction

1. The operator interface (Web based GUI) shall allow the operator to perform commands within any BAS controller on the BAS local area network including, but not limited to, the following:

    - Start-up or shutdown of all equipment converted to the BAS.
    - Adjust, override, and release setpoints
    - Add/Modify/Delete programming
    - Enable/Disable process execution
    - Limit setpoint adjustment range of zone sensors.
    - Lock/Unlock alarm reporting for each point
    - Enable/Disable Totalization for each point
    - Enable/Disable Trending for each point
    - Enter temporary override schedules
    - Define Holiday Schedules
    - Change time/date
    - Enter/Modify analog alarm limits
    - Enter/Modify analog warning limits
    - View limits

2. All control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.

3. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:

    - Add/Delete/Modify Standalone BAS Panels
    - Add/Delete/Modify Application Specific Controllers
    - Add/Delete/Modify points of any type, and all associated point parameters, and tuning constants
    - Add/Delete/Modify alarm reporting definition for each point
    - Add/Delete/Modify control loops
    - Add/Delete/Modify energy management applications
    - Add/Delete/Modify time- and calendar-based programming
    - Add/Delete/Modify Totalization for every point

- Add/Delete/Modify Historical Data Trending for every point
- Add/Delete/Modify custom control processes
- Add/Delete/Modify any and all graphic displays, symbols, and cross-references to point data
- Add/Delete/Modify all operator passwords
- Add/Delete/Modify Alarm Messages

4. Definition of operator device characteristics, BAS panels, individual points, applications and control sequences shall be performed through fill-in-the-blank templates.

F. Reports

1. Reports shall be generated automatically or manually, and directable via operator input to GUI monitors, printers, or disk files. As a minimum, the system shall allow the user to easily obtain the following types of reports:

   - A general listing of all points in the network
   - List all points currently in alarm
   - List of all off-line points
   - List all points currently in override status
   - List of all disabled points
   - List all points currently locked out
   - List of all items defined in a “Follow-Up” file
   - List all Weekly Schedules
   - List all Holiday Programming
   - List of Limits and Deadbands

2. Summaries shall be provided for specific points, for a logical point group, for a user-selected group of groups, or for the entire facility without restriction due to the hardware configuration of the BAS.

G. Third Party Software Interface

1. System data, including transactions, alarms, totalization files, etc., shall be stored on the LANL BAS server hard drive in a format compatible with Microsoft database and spreadsheet programs.

H. Dynamic Color Graphic Displays

1. Software for development of BAS color graphic site plans, buildings, building floor plan displays, and system schematics for each piece of mechanical equipment, including air handling units, chilled water systems, hot water boiler systems, and all other controlled or monitored systems shall be provided as specified in PART 3 of this specification.

2. Dynamic point (actual or calculated) indication shall be shown in their respective locations, and shall automatically update to represent current conditions without operator intervention.

I. Database Save/Restore/Back-Up

1. Back-up copies of all standalone BAS panel databases shall be stored on the appropriate LANL BAS server. The contractor shall backup all affected databases each day after modifications are made.

2. Continuous supervision of the integrity of all BAS panel databases shall be provided. In the event that any BAS panel on the network experiences a loss of its data base for any reason, the system shall automatically download a the latest updated copy of the respective database to restore proper operation. Database back-up/download shall occur without operator intervention. Operators shall also have the ability to manually execute uploads and downloads of any or all portions of a BAS panel database to or from the appropriate LANL BAS server.

J. Graphic Generation Software

1. Graphic generation software shall be provided to allow the engineering user to add, modify, or delete system graphic displays.

2. A complete standard library of pre-engineered screens and symbols depicting standard air handling unit components (e.g. fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g. constant volume-terminal reheat, VAV, etc.), instrument, and electrical symbols shall be provided.

3. The graphic development package shall use a mouse in conjunction with a drawing program to allow the user to perform the following:

    - Define symbols
    - Position and size symbols
    - Define background screens
    - Define connecting lines and curves
    - Locate, orient and size descriptive text
    - Define and display colors for all elements
    - Establish correlation between symbols or text and associated system points

K. Graphic Programming Software

1. A Graphic Programming Language (GPL) software package shall be provided that allows fully graphic programming of all BAS control algorithms resident in BAS controllers. Any system that does not use a drag and drop method of graphical icon programming as described herein shall be unacceptable.

2. The following is a definition listing for the capabilities described for the Graphic Programming software:

    a. Function Block (FB) - Shall be a collection of points, micro-blocks and wires that have been connected together for the specific purpose of controlling a piece of HVAC equipment or a single mechanical system.

b. Logical I/O - Input/Output points that shall interface with the control modules in order to read various signals and/or values or to transmit signal or values to controlled devices.

c. BACnet™ Points - points that comply with the BACnet™ structure as defined in the same standard.

d. Microblocks - software devices that are represented graphically and may be connected together to perform a specified sequence.

e. Wires - graphical elements that are used to form logical connections between microblocks and between microblocks and logical I/O. Different wires types shall be used depending on whether the signal they conduct is analog or digital.

f. Labels - shall be similar to wires in that they are used to form logical connections between two points. Labels shall form a connection by reference instead of a visual connection, e.g. two points labeled ‘”A” on a drawing are logically connected even though there is no wire between them.

g. Parameter - shall be a value that may be tied to the input of a microblock. Each parameter shall then be displayed on the resulting FB parameter page and can be modified to varying degrees based upon the appropriate password level being used by the operator. Different parameter microblocks shall be used depending on whether the parameter is digital or analog.

h. Constant - shall be similar to a parameter except that it is displayed only in the graphic FB file itself and not be displayed on any parameter page. Certain coefficients that are used in various calculations always remain constant and therefore should be constants that are embedded in the program and not parameters. Different constant microblocks shall be used depending on whether the constant is digital or analog.

i. Properties - Dialog boxes shall appear after a microblock has been inserted that has editable parameters associated with it. Default parameter dialog boxes shall contain various editable and non-editable fields and shall contain push buttons for the purpose of selecting default parameter settings.

j. Icon - shall be graphic representation of a software program. Each graphic microblock has an icon associated with it that graphically describes it function.

k. Menu-bar Icon - an icon that is displayed on the menu bar on the GPL screen that represents its associated graphic microblock.

i. GPL is a method used to create sequences of operations by assembling graphic microblocks that represent each of the commands necessary to complete a control sequence. Microblocks represent common logical control devices used in conventional control systems, such as relays, switches, high signal selectors, etc., in addition to the more complex BAS and energy management strategies such as PID loops and optimum start. Each microblock shall be interactive and contain the programming necessary to execute the function of the device it represents.

ii. Graphic programming shall be performed while on screen. Each microblock shall be selected from a microblock library and assembled with other microblocks necessary to complete the specified sequence. Microblocks are then interconnected on screen using graphic "wires", each forming a logical connection. Once assembled, each logical grouping of microblocks and their interconnecting wires forms a graphic function block that may be used to control any piece of equipment with a similar point configuration and sequence of operation.

iii. The clarity of the graphic sequence shall be such that the user has the ability to verify that system programming meets the specifications, without having to learn or interpret a manufacturer's unique programming language. The graphic programming shall be self-documenting and provide the user with an understandable and exact representation of each sequence of operation.

iv. Full simulation capability shall be provided with the GPL. Users shall be able to fully simulate the constructed sequence on screen before the sequences are downloaded into the controllers. The GPL shall also include the ability to simulate multiple graphic programs communicating with each other on a simulated network. The simulation shall show each output value and how it varies in relation to an artificial time clock. The time clock may run at normal time increments, increased increments (fast motion) or decreased increments (slow motion).

2.6 GATEWAY CONTROLLERS (GWC)

A. The Gateway Controller (GWC) shall be a microprocessor-based communications device that functions as a communications gateway/router between a Controller LAN and the Primary LAN. It shall be capable of acting as a bridge and router between designated BACnet™ data links and the ARCNET data link. It shall offer PTP to ARCNET and BACnet/IP to ARCNET routing capability.

B. The Primary LAN that connects GWCs in other buildings exists and development of that LAN is not work of this section. The Primary LAN is configured as an Ethernet 10/100Base-T (10 or 100Mbps) or Gigabit Ethernet (future) network

operating over fiber-optic cable. In the case of Ethernet connections, the LAN Gateway may be configured as Ethernet 10/100Base-T(10/100Mbps), and shall be CAT5 or current industry standard cable that exceeds CAT5 specifications

C. Each GWC shall support a building Controller LAN on which shall reside Primary Controllers, Application Specific Controllers, or Unitary Controller Interfaces.

D. The Controller LAN shall use the BACnet™ communication protocol. The communication between controllers shall be at least 156 Kbps using ARCNET implemented over EIA-485 at the Data Link Layer.

E. The GWC shall provide two EIA-232 ports that can be connected to future portable computers or modems.

F. The GWC shall provide full arbitration between multiple users, whether they are communicating through the same or different GWCs.

G. The GWC shall be responsible for routing global information from the various building Controller LAN's that may be installed throughout a building or multiple buildings.

H. The GWC shall utilize FLASH memory that allows firmware updates to be performed remotely.

2.7 PRIMARY BAS CONTROLLERS (PFC)

A. Primary BAS Controllers (PFCs) shall be provided where larger non-application specific I/O is installed. Such applications could include central chiller plants, boiler plants, larger built up air handling units with special point and software requirements. PFCs shall reside on the Controller LAN and their point information shall be fully accessible by the GWC

B. PFCs shall use the BACnet™ communication protocol for communication with all other Controller LAN controllers and shall, at a minimum, support the following Objects and Application Services (Conformance Class 3):

Objects >	Binary Input	Services >	Read property
	Binary Output		Write property
	Binary Value		I-Am
	Analog Input		I-Have
	Analog Output		Read Multiple Property
	Analog Value		Write Multiple Property
	Calendar		Who-Has
	Schedules		Who-Is

C. Each PFC shall be capable of standalone direct digital operation utilizing its own 32-bit processor, non-volatile flash memory, input/output, 12-bit A-to-D conversion, hardware clock/calendar, and voltage transient and lightning protection devices. All non-volatile flash memory shall have a battery backup of at least five years. Firmware revisions to the module shall be able to be made from the LANL BAS server, portable operator terminals (future), or from remote locations over modems or LANs.

D. Each PFC shall be expandable to the specified I/O point requirements and shall accommodate multiple I/O Expander Modules via a designated expansion I/O bus port. These expander modules shall expand the total point capacity of each controller up to 192 points where specified. The controller, in conjunction with the expansion modules, shall act as one standalone controller. The contractor shall provide 30% spare hardware I/O capacity.

E. All point data, algorithms, and application software within a PFC shall be custom programmable from the Web based GUI with appropriate password level.

F. Each Primary BAS Controller shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for application programs residing in each PFC shall be stored in read/writable nonvolatile flash memory within the PFC and shall be able to upload/download to/from the LANL BAS server via the Web based GUI with appropriate password level.

G. Each PFC shall include self-test diagnostics that allow the PFC to automatically relay to the GWC any malfunctions or alarm conditions that exceed desired parameters as determined by programming input.

H. PFCs shall contain both software and firmware to perform full DDC PID control loops.

I. Each PFC shall contain a serial or USB port for the interface of maintenance personnel's portable computer (future). All network interrogation shall be possible through this port.

J. Input-Output Processing:

1. Digital outputs shall be relays, 24VAC or VDC maximum, 3 amp maximum current. Each configured as normally open or normally closed using jumpers and either dry contact or bussed. Triac outputs are unacceptable. Each output shall have a manual Hand-Off-Auto switch, to allow for override and an LED to indicate the operating mode of the output.

2. Universal inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77EF (25EC), 0-5VDC, 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power 250 Ohm input impedance, dry contact - 0.5mA maximum current.

3. Analog output shall be electronic, voltage mode 0-10VDC or current mode 4-20mA.

4. Analog pneumatic outputs shall be 0-20psi. Each pneumatic output shall have a feedback transducer to be used in the system for any software programming needs. The transducer shall measure the actual psi output value and not a calculated value. Each output shall have a manual override switch that shall allow each output to be configured in one of three ways: open, closed, or automatic operation. An LED shall indicate the state of each output.

2.8 APPLICATION SPECIFIC CONTROLLERS

A. Application Specific Controller (ASCs) shall be provided where small application-specific I/O is installed. Such applications include packaged rooftop equipment, packaged chiller controllers, and exhaust fan control. Multiple Application Specific Controllers (ASCs) shall not be employed to substitute for a single PFC. ASCs shall reside on the Controller LAN and their point information shall be fully accessible by the GWC.

B. The ASC shall use the BACnet™ communication protocol to communicate with all other Controller LAN controllers and shall, at a minimum, support the following Objects and Application Services (Conformance Class 3):

Objects >	Binary Input	Services >	Read property
	Binary Output		Write property
	Binary Value		I-Am
	Analog Input		I-Have
	Analog Output		Read Multiple Property
	Analog Value		Write Multiple Property
	Calendar		Who-Has
	Schedules		Who-Is

C. Each ASC shall be capable of stand-alone BAS operation utilizing its own 32-bit processor, nonvolatile flash memory, input/output, 10-bit A-to-D conversion, hardware clock/calendar, and voltage transient and lightning protection devices. All nonvolatile Flash memory shall have a battery backup of at least five years. Firmware revisions to the module shall be made from the LANL BAS server, Web based GUI.

D. All point data, algorithms, and application software within the ASCs shall be custom programmable from the Web based GUI.

E. Each ASC shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the controller. All operating parameters for the application program residing in each ASC shall be stored in read/writable nonvolatile flash memory within the ASC and shall be able to upload/download to/from the LANL BAS server via the Web based GUI with appropriate password level.

F. Each ASC shall include self-test diagnostics that allow the ASC to automatically relay to the GWC any malfunctions or alarm conditions that exceed desired parameters as determined by programming input.

G. Each ASC shall contain both software and firmware to perform full DDC PID control loops.

H. A serial or USB port shall be provided for the interface of maintenance personnel's portable computer. All network interrogation shall be possible through this port.

I. ASCs shall be capable of being operated in an ambient temperature environment of -20°F to +150°F (-28.9°C to 65.6°C).

J. Input-Output Processing:

1. Digital outputs shall be relays, 24VAC or VDC maximum, 3 amp maximum current. Triac outputs are unacceptable. Each output shall have a manual Hand-Off-Auto switch to allow for override and an LED to indicate the operating mode of the output.

2. Universal inputs shall be Thermistor (BAPI Curve II) 10K Ohm at 77EF (25EC), 0-5VDC - 10K Ohm maximum source impedance, 0-20mA - 24 VDC loop power 250 Ohm input impedance, Dry Contact - 0.5mA maximum current.

3. Analog electronic outputs shall be voltage mode 0-10VDC or current mode 4-20mA.

4. Enhanced Zone Sensor Input shall provide one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator.

2.9 UNITARY CONTROLLER INTERFACE

A. Unitary Controller Interfaces (UCIs) shall be provided where small unitary type controllers are required but these small controllers are not capable of direct connection to the Controller LAN. UCIs shall reside on the Controller LAN.

B. The UCI shall use the BACnet™ communication protocol to communicate with all other Controller LAN controllers and shall, at a minimum, support the following Objects and Application Services (Conformance Class 3):

Objects >	Binary Input	Services >	Read property
	Binary Output		Write property
	Binary Value		I-Am
	Analog Input		I-Have
	Analog Output		Read Multiple Property
	Analog Value		Write Multiple Property
	Calendar		Who-Has
	Schedules		Who-Is

C. The UCI shall use the BACnet™ protocol for communication to the attached UCs over the Sub-Controller LAN. The communication speed between Sub-Controller LAN shall adjustable from between 9600 baud to 115.2 kbps.

D. A serial or USB port shall be provided on the UCI for the interface of the operators' portable computer (future). All network interrogation shall be possible through this port.

E. Each UCI shall execute application programs, calculations, and commands via a 32-bit microcomputer resident in the UCI. All operating parameters for application programs residing in each UCI shall be stored in read/writable nonvolatile flash

memory within the controller and shall be able to upload/download to/from the LANL BAS server via the Web based GUI with appropriate password level. All nonvolatile memory shall have a battery backup of at least five years. Firmware revisions to the controller should be able to be made from the LANL BAS server via the Web based GUI.

F. The UCI shall contain both software and hardware to perform full DDC PID control loops.

G. UCI Circuits shall be optically isolated.

2.10 UNITARY CONTROLLERS

A. Each Unitary Controller (UC) shall use the BACnet™ communications protocol for communication with the UCI and the other UCs on the Sub-Controller LAN and shall, as a minimum, support the following Objects and Application Services (Conformance Class 2):

Objects >	Binary Input Analog Value	Services >	Read property Write property

B. Each UC shall be able to support various types of zone temperature sensors, such as temperature sensor only, temperature sensor with built-in local override switch, with set point adjustment switch.

C. Each UC for VAV application shall have a built-in airflow transducer for accurate (+/- 5.0% F.S.) airflow measurement in order to provide the pressure independent VAV operation.

D. Each UC for VAV applications shall have an integral direct-coupled electronic actuator. The actuator shall provide on-off/floating point control with a minimum of 35 in-lb of torque. The assembly shall mount directly to the damper operating shaft with a universal V-Bolt clamp assembly. The actuator shall not require any limit switches, and shall be electronically protected against overload. When reaching the damper or actuator end position, the actuator shall automatically stop. The gears shall be manually disengaged with a button on the assembly cover. The position of the actuator shall be indicated by a visual pointer. The assembly shall have an anti-rotational strap supplied with the assembly that shall prevent lateral movement.

E. Each UC and UCI shall have LED indication for visual status of communication, power, and all outputs.

F. In the event of a loss of communication with the UCI, each UC shall control from a standalone algorithm that maintains the assigned space temperature until communication with the UCI is restored.

G. Input/Output Processing:

1. Digital outputs shall be relays, 24VAC or VDC maximum, having a 3 Amp maximum current. Each relay shall be configured as normally open or

normally closed, and either dry contact or bussed. Triac outputs are not acceptable.

2. Universal inputs shall be Thermistor Precon Type II, dry contacts or 0-5VDC with 0-10K Ohm input impedance.

3. One input shall be provided for an enhanced space sensor. This sensor input capability shall include one thermistor input, one local setpoint adjustment, one timed local override switch, and an occupancy LED indicator.

4. Analog output, voltage mode 0-10VDC or current mode 4-20mA.

2.11 ELECTRONIC TEMPERATURE ELEMENT AND TRANSMITTER

A. Zone Space Sensors

1. Each UC or ASC controlling a single zone application shall be provided with a space temperature sensor. The space sensor shall include a thermistor packaged in the standard UC/sensor design, timed override button, set point adjustment, and a maintenance communication port.

B. All Other Temperature Sensors

1. All Temperature sensors connected to a PFC or an ASC shall be a Type II Thermistor compatible with the attached BAS controller without the need for any signal conversion hardware. The accuracy of the thermistor shall be +/- 0.5^{o}F over the range of the sensor. Manufacturer/Model: Precon ST series.

2. Sensors used for mixed air applications shall be 25' averaging type. The sensor span shall have a field set range of 32.0^{o}F to 160.0^{o}F.

3. Duct temperature sensors for supply air temperatures and return temperature shall be a minimum of 18" in length. The sensor span shall have a range of -30.0^{o}F to +160.0^{o}F.

4. Sensors used for outdoor air temperature shall be provided complete with a sunshield. The sensor span shall have a range of -30.0 ^{o}F to +140.0 ^{o}F.

5. All chilled water sensors and sensors placed in locations susceptible to condensation (outside or in chilled and condenser water liquid lines with the potential to drop below the ambient dew point) shall be furnished complete with a NEMA 3R enclosure for the electronics.

6. All immersion water sensors shall have an immersion length of one half the pipe diameter plus the length of the pipe tap. The sensors shall have a range of +10.0 ^{o}F to +230.0 ^{o}F. Units shall be furnished complete with a brass thermowell.

2.12 CURRENT TRANSDUCERS

A. Current sensing transducers shall measure the AC current of loads and shall output a 4-20 mA DC signal over the measured range of 0 to 20 amps AC. If the load is in excess of 20 amps AC, a step down current transformer shall be selected for the actual range of the load and used in conjunction with the current transducer. Manufacturer/Model: Neilsen-Kuljian 4CMA Series.

2.13 CURRENT SENSING SWITCH

A. Current sensing relays shall indicate the presence of AC current. The transistor switches shall be rated for switching controller DC current up to 150 mA continuously at 30 VDC or 500 mA momentarily at 30 VDC. The setpoint of the contact operation shall be field adjustable from 1 to 150 amps AC. The switch shall be self-powering with an applied power indication LED and a second switched load LED for local indication. Manufacturer/Model: Neilsen-Kuljian PD75 Series.

2.14 AIR DIFFERENTIAL PRESSURE SWITCHES

A. Air differential pressure switches shall have an adjustable setpoint of from 0.05" W.C. to 12.0" W.C. Manual reset shall be provided where indicated on the drawings. One snap acting SPDT Type C switch shall be enclosed under a NEMA 1 enclosure with a 1/2" conduit opening. Contacts shall be rated for 10 amps at 120 VAC. Manufacturer/Model: Cleveland AFS series.

2.15 ELECTRIC LINE VOLTAGE THERMOSTAT

A. The thermostat shall be of the bimetallic design with a SPDT set of contacts rated for 120 VAC at 25 amps. Thermostat shall have an adjustable set point of from 50 to 86^0 F with a fixed differential of 2.0^0F. The cover shall be metal. Manufacturer/Model: Barber-Coleman Model No. TC-195.

2.16 ELECTRIC FLOW SWITCH

A. The switch shall utilize a multi-segment paddle for use in pipes ranging in size from 1" to 8" with a maximum operating pressure of 150 PSIG and utilize a sealed bronze bellows (packless construction). A snap-acting SPDT switch rated for 16.0 amps at 120 VAC shall be installed in a NEMA 1 enclosure with 1/2" conduit knockout is used for indoor applications. A NEMA 4 enclosure with threaded 1/2" rigid conduit connection is used in all outdoor or high humidity applications, on liquid lines handling fluids below ambient dewpoint or as indicated on the drawings. Manufacturer/Model: Johnson F61 series.

2.17 LIQUID DIFFERENTIAL PRESSURE SWITCH

A. Switch shall have an adjustable set point of from 3 to 30 PSIG and a minimum differential of 2 PSIG. One snap acting SPDT switch enclosed under a NEMA 1 enclosure with 1/2" conduit opening and rated for 12 amps at 120 VAC shall be provided. Manufacturer/Model: Johnson P74 series.

2.18 CONTROL RELAYS

A. Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting silver cadmium Form C contacts, enclosed in dust proof enclosure. Relays shall be equipped with the necessary mounting base, DIN rail, labels, termination clips, etc. and a coil transient suppression devices. All relays for control by the BAS shall have 24 VAC coils. All other required relays shall have coil voltages appropriate for the installation. Manufacturer/Model: IDEC RH Series.

2.19 CONTROL TRANSFORMERS

A. Control transformers required for all other control purposes including control of pilot duty relays, power supplies, damper and valve actuators, etc. shall be provided. Control transformers 100 VA and less may have internal secondary overload if desired but anything over 100 VA shall be external fused. In no case shall a transformer have a capacity less than 65% of the attached load.

2.20 AUTOMATIC DAMPERS

A. All automatic dampers shall be furnished under this section of the specifications unless provided as part of the equipment.

1. Control Dampers not required for measurement of outside air velocity pressure shall be constructed of galvanized steel with synthetic or Teflon bearings and trunnions of non-corrosive materials. Each blade shall have a positive closing butyl-rubber or neoprene edge seal, and spring loaded side seals unless otherwise noted. Dampers shall be designed so that the blades are interconnected to give parallel movement. Jack shafting shall be provided for all dampers greater than 24” x 48” and damper shaft extensions shall be provided for connection of damper actuators outside the duct.

    a. Parallel Blade Dampers: Provide parallel blade type automatic dampers for return air, two position, the face section of face and bypass dampers, and where indicated on the drawings.

    b. Opposed Blade Dampers: Provide opposed blade type dampers for volume control, exhaust and outside air dampers of a mixing section, throttling application and, where indicated on drawings.

    c. Manufacturer/Model: Ruskin CD-36

2.21 DAMPER ACTUATORS

A. Modulating and Two-Position Damper Actuators

1. The actuator shall be of the direct-coupled design. The fastening clamp assembly shall be of a “V” bolt design with associated “V” shaped toothed cradle attaching to the shaft for maximum strength and eliminating slippage. Spring return actuators shall have a “V” clamp assembly of sufficient size to be directly mounted to an integral jackshaft of up to 1.05 inches when the damper is constructed in this manner. Actuators shall be designed for a

minimum of 60,000 full stroke cycles at the actuator's rated torque and shall have a two (2) year manufacturer's warranty, starting from the date of installation.

2. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the entire rotation of the actuator. Mechanical end switches or magnetic clutch to deactivate the actuator at the end of rotation are not acceptable. For power-failure/safety applications, an internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable.

3. Spring return actuators shall be provided for all outside and exhaust/relief air dampers in addition to all locations indicated on the drawings. Spring return actuators shall be capable of both clockwise or counterclockwise spring return operation by simply changing the mounting orientation

4. Proportional actuators shall accept Pulse Width Modulation (PWM) control signaling and power from a 24 VAC source, 4-20 mA, or Tri-State control. Two position actuators shall be 24 VAC with spring return.

5. All actuators shall not require more than 10 VA regardless of the operating voltage.

6. Actuators shall be provided with a conduit fitting and a minimum three-foot electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.

7. Manufacturer: Belimo

2.22 CONTROL VALVES

A. Ball Control Valves

1. Valves to be two-way industrial quality with bronze bodies and female NPT threads or flange connections. Valve bodies may also be stainless steel, titanium or nickel with operating pressure up to 2000 psi.

2. All valves shall have blowout-proof stem, glass-reinforced Teflon thrust seal washer and stuffing box ring with minimum 600 psi rating. Stem packing gland screw shall be adjustable for wear.

3. Standard chromium plated stainless steel ball and stem, shall be rated at a minimum of 600 psi WOG (water-oil-gas), cold, non-shock, and 150 psi for saturated steam service. All valves shall be provided with Reinforced Teflon seats.

4. Valve actuators shall be factory mounted and provided as described in "Valve Actuators."

5. Manufacturer: Delta

B. Two- and Three-Way Globe Control Valves Two Inches and Less

1. Valves 1/2 inch through 2 inches shall be bronze, screw type, and shall be rated at 250-psi maximum working pressure for water and steam.

2. Valve stems shall be stainless steel, highly polished, corrosion-resistant, alloy to decrease friction and increase response. Valve plugs shall be brass and guided to insure perfect seating.

3. Stem packing shall be spring loaded EP V-Rings for water applications and Teflon V-Rings for steam applications to eliminate leakage around the stem and insure a minimum amount of stem friction. Stem lift shall be 1/2 inch to 3/4 inch.

4. Flow type shall be equal percentage for water. The maximum operating differential shall be 10 psi for water.

5. Manufacturer/Model: Johnson Controls VA-8000 series

C. Two- and Three-Way Globe Control Valves Greater than Two Inches

1. Valves 2-1/2 inches through 6 inches shall be cast iron flanged, and rated at 125-psi maximum working pressure. The maximum working temperature shall be 300^0F/149^0C.

2. Valve plug stems shall be stainless steel, highly polished, corrosion-resistant, alloy to decrease friction and increase response. Valve plugs shall be brass and guided to insure perfect seating. Stem packing shall be Teflon, spring loaded EP V-rings to eliminate water leakage around the stem and insure a minimum amount of stem friction. Lift shall be 3/4 inch to 1-1/2 inch.

3. Flow type shall be equal percentage. The maximum recommended differential shall be 10 psi. Composition discs shall be replaceable and provide tight shutoff.

D. Control Two- and Three-Way Butterfly Valves

1. All butterfly valves shall be supplied in accordance with the requirements of this and other applicable Sections.

2. Three way butterfly control valves shall be supplied complete with flanged pipe tees and all linkage necessary to cross-link the two valves.

2.23 CONTROL VALVE ACTUATORS

A. Electronic Valve Actuators

1. All ball and globe valves actuator shall be fully modulating using a 4-20 mA input signal. There shall be a visual valve position indicator. Control power shall be 24 VAC and shall not exceed 8 watts at 24 VAC. The actuator shall provide minimum torque required for proper valve close-off, with an approximate running time of 2 minutes for full rotation. The actuator shall be designed with current limiting motor protection. (End of travel switches and magnetic clutches are not acceptable.) A release button on the actuator shall be provided to allow for manual override, except when utilizing spring return actuators.

2. The actuators and valves shall be factory mounted and tested and supplied.

3. Manufacturers:

   a. Ball valves: Delta

   b. Globe two-way and three-way control valves: Belimo

B. Butterfly Valve Actuators

1. Electronic actuators and linkages shall be factory mounted with each butterfly valve as shown on the control drawings.

2. Modulating valves shall be shall be complete with positioners to modulate the valve with a 4-20 mA input signal. All automatic valves shall have provision shall be made for hand activation of the valve in the event of an actuator failure. Valve actuator shall be powered from 120 VAC. Actuators shall be selected so as to provide positive shut off based on the system operating parameters.

3. Actuators and positioning relays shall be NEMA 4 rated for installation in wet locations. Sun shields shall also be provided for all actuators and positioners installed in locations exposed to direct sunlight.

4. Actuators shall be factory mounted, tested, and supplied.

5. Manufacturer/Model: Keystone Model 777

   a. Two-Position Butterfly Valve Actuators

      i. Outside the scope of this Section.

2.24 INPUT/OUTPUT AND INTERLOCK WIRING

A. Class I circuits

1. All materials required for installation of Class I circuits or circuits operating at greater than 48 VAC or VDC shall meet the requirements stated in Division

16, National Electric Code, and all applicable building codes as they apply to Class I circuits.

B. Class II circuits

1. All materials required for installation of Class II circuits shall meet all requirements of the National Electric Code and all applicable building codes as they apply to Class II circuits.

2. Cable run exposed in plenums where permitted shall contain twisted conductors or pairs of twisted conductors no smaller than 18 gauge. The number of conductors shall be as required by the application and an overall foil shield with stranded drain wire shall be provided in all cases. The cable shall be factory stamped with a clear indication of the cable classification. The cable jacket shall be Teflon or other approved materials that comply with the smoke generation limitations outlined in Article 725 of the NEC, U.L, and all requirements of the NFPA.

3. Cable run in a metallic raceway shall contain twisted conductors or pairs of twisted conductors no smaller than 18 gauge. The number of conductors shall be as required by the application and an overall foil shield with stranded drain wire shall be provided in all cases. The cable shall be factory stamped with a clear indication of the cable classification and number of pairs. The cable jacket shall be PVC. Metallic raceway shall be as specified in Division 16.

2.25 REFRIGERANT VAPOR DETECTOR

A. Provided in accordance with the applicable codes.

2.26 INDOOR AIR QUALITY SENSOR

A. The IAQ sensor shall be specifically designed to generate a linear 0-10 VDC signal proportional to a 0.0 to 100% air quality unit where 0.0% is very poor, 100% is very good, and 50% is average. The components making up the air quality measurement shall include CO2, CO, hydrocarbons, methane, formaldehyde, etc. Mount the sensor directly on a duct and power with a 24 VAC power source. Manufacturer/Model: Staefa FKA-Q1A.

2.27 DUCT STATIC PRESSURE STATION

A. Provide at each duct static pressure measuring location a traverse probe capable of continuous monitoring of static pressure. The probe shall contain multiple static pressure pick-up points along the exterior surface of the cylindrical probe, internally connected to their respective averaging manifold. Each probe shall be extruded aluminum construction with threaded end support rod and nut, and mounting plate with gasket. Each probe shall be sized to span the entire duct and not extend past either side. The probe shall not produce a measurable pressure drop and shall produce a non-pulsating signal with an accuracy of 0.5 percent of total span. Manufacturer/Model: Air Monitor Model STAT-Probe/1.

2.28 DUCT VELOCITY STATION

A. Install per manufacturer's instructions to insure proper duct diameters upstream and downstream of flow measuring station. Provide at each location indicated, traverse probes capable of continuous monitoring of total and static pressure pick-up points, along the exterior surface of the cylindrical probe, each internally connected to their respective averaging manifold. Multiple probes, required for specified accuracy, shall be externally connected in a parallel configuration. Each probe shall be extruded aluminum construction with installation hardware specifically designed for duct mounting. The probes shall produce a non-pulsating signal with an accuracy of 99% of total system flow. Manufacturer/Model: Air Monitor Model VOLU-Probe/1.

2.29 OUTSIDE AIR STATIC PRESSURE PROBE

A. Outside air static pressure probe shall be constructed of 10-gauge anodized aluminum with a 2" diameter FPT connection. The probe shall be capable of sensing the outside atmospheric air pressure to within 2% of the actual value when subject to radial wind velocities up to 80 miles per hour with approach angles up to 30 degrees to the horizontal. Manufacturer/Model: Air Monitor S.O.A.P.

2.30 ELECTRONIC DIFFERENTIAL PRESSURE TRANSMITTER

A. Electronic differential pressure transmitter shall be designed to measure the differential air pressure as indicated on the drawings or as required. Pneumatic connections shall be 1/4" barbed and the enclosure shall be provided with holes for panel or field mounting. The output shall be a two-wire 4-20 mA loop-powered device with an input range as indicated in the drawings but not more than twice the actual measure variable. The accuracy, including linearity, hysteresis, and repeatability, shall be less than ±2%. Manufacturer/Model: Modus Series T30.

2.31 ELECTRONIC AIR FLOW ELEMENT AND TRANSMITTER

A. Probes shall be supplied complete with curved duct mounting plate and gasket and the probe shall be constructed of stainless steel. The associated transmitter shall process the flow signal, automatically amplify, and linearize the thermal

sensor signal. The indicating transmitter units shall be remote panel mounted and shall have a 3.5 digit, 0.5 " high LCD display and that is calibrated to display flow rate in SCFM. The unit power is 24 VAC, 3-watt power input and the output is 4-20 mA signal linear to the measured airflow rate. The unit selected has a maximum flow rate. Manufacturer/Model: Air Monitor Electra/1 Model C/D.

2.32 ELECTRONIC LIQUID FLOWMETER

A. The flowmeter shall be of the paddle wheel insertion type allowing complete bi-directional flow that penetrates into the line. The flowmeter shall be furnished complete with a flow transmitter that supplies a 4-20 mA or 0-10 VDC signal for each direction as well as a directional signal. Meter shall have an accuracy of no less then 2% of the actual reading over the range of the meter. Meter shall include all necessary equipment to allow the flow meter to be inserted or removed without draining the system. Manufacturer: Onicon

2.33 ELECTRONIC HUMIDITY TRANSMITTER

A. The sensors shall have an accuracy of ± 3.0% R.H. over the range of 10 to 90% R.H. with an operating temperature range of at least -20 to 60 degrees Celsius. The transmitter shall output a 4-20 mA DC loop powered signal over the full range of the transmitter and the input impedance shall not exceed 500 ohms at 20 VDC. The transmitter shall be specifically designed for use in measuring outdoor or duct humidity or indoor space applications as indicated.

1. Outdoor or duct mounted units shall be enclosed in a NEMA 4 enclosure with a black-painted aluminum casing. Manufacturer/Model: Vaisala Model No. HMD 20U.

2. Space transmitter Manufacturer/Model: KELE Model No. HW10K

2.34 ELECTRIC LOW LIMIT (FREEZESTAT)

A. Freezestat shall have a 20o temperature sensitive element designed to respond to the lowest temperature to which any 1 foot length of the element is exposed. The unit shall have an adjustable set point of from 350F to 450F. The electrical rating of the two SPDT contacts shall be 10.2 full load amps at 120. Unit shall be complete with an external manual reset lever. Manufacturer/Model: Johnson A70 series.

2.35 SMOKE AND FIRE DETECTORS

A. Smoke detectors installation is outside the scope of this section; see Section 13851[or 16721].

2.36 CONTROL PANELS

A. All indoor control cabinets shall be fully enclosed NEMA 1 Type construction with hinged door, key-lock latch, removable sub-panels. A single key shall be common to all field panels and sub-panels.

B. Provide on/off power switch with over-current protection for control power sources an include a service outlet for main panels where a lap-top is required for controller configuration.

C. The design and workmanship shall comply with the requirements of underwriters laboratories (UL) Bulletin 508 by affixing a UL 508 compliance label to the interior of each panel.

D. Conform to applicable UBC for flame/fuel/smoke rating and ventilation requirements for application of finishes.

E. All individual panel components shall be UL listed.

F. Panels shall have no exposed terminals that may be inadvertently touched (i.e., terminal screws shall be in wells). A plastic protective guard shall be provided for all exposed terminals greater than 50 VAC or 50 VDC.

2.37 ELECTRICAL POWER AND SIGNAL WIRING

A. Control and signal wiring external to the control panels and all power wiring shall conform to the requirements of Division 16 specifications and the equipment manufactures recommendations for the equipment it is connected to.

B. Power to the BAS shall be provided from dedicated circuits. Providing power to any BAS components from lighting circuits, receptacle circuits or any other circuit that serves other building general loads is unacceptable. Providing power from primary BAS control panels to controllers and sub-controllers is acceptable.

C. Control and signal wiring in control panels shall be restrained by plastic ties or ducts. Hinge wiring shall be secured at each end so that any bending or twisting will be around the longitudinal axis of the wire and the bend area shall be protected with a sleeve.

D. Arrange wiring neatly, cut to proper length, and remove surplus wire. Provide abrasion protection for any wire bundles which pass through holes or across edges of sheet metal.

E. Use manufacturer's recommended tool with the proper sized anvil, for all crimp terminations. No more than one wire may be terminated in a single crimp lug and no more than two lugs may be installed on a single screw terminal.

F. Wiring shall not be spliced or tapped except at device terminals or terminal blocks.

G. Provide wire markers per Division 16 specifications on each conductor in the panel, at load connections, and at intermediate terminal blocks. Identify circuit with control wire number, as per Drawings.

H. The Contractor will be responsible for providing, installing, labeling, terminating, control and control power wiring as well as the BAS communications system (Ethernet) wiring.

I. Connection of field wiring shall be made on the terminal blocks in the PLC control panels.

PART 3 EXECUTION

3.1 GENERAL

A. All field hardware, control devices, conduit, wiring, etc. shall be provided as specified in PART 2.

1. The installation of all aspects of the system shall comply with all applicable codes, regulations, and all related Contract Documents.

2. The installation of all materials shall be in accordance with the published manufacturer's recommendations without exception. If for some reason a particular component cannot be installed in compliance with these recommendations, the Contractor shall advise the LANL Construction Inspector of the situation.

3. Where miscellaneous materials are required to complete an installation, e.g. isolation valves for pressure switches, wall switches for an exhaust fan control circuit, etc., the materials shall be supplied as defined in the relevant section of these specifications and installed under this section of the specification, unless otherwise noted.

4. Coordinate with other trades where installation of a particular component requires other trades to be involved. Installation coordination includes location the correct placement of thermowells, flow switches, dampers, control valves, control power circuits, etc. Care shall be exercised to identify locations that meet the requirements of the manufacture including upstream and downstream distances, pressures, temperatures, etc.

5. All signal wiring requiring shielding shall have the shield terminated at the controller end only. The shield wire shall be trimmed and insulated at the device end.

6. Label all wiring with permanent labels indicating the point device identifier. Install a phenolic label mounted at the device indicating the device type and point identifier name.

7. All field devices shall be labeled with 1" x 3" phenolic labels. Labels shall include the point name and device name. Labels for BAS controllers shall indicate the breaker and panel number of the power source. Labels shall be glued, attached with screws, or stainless wire in the case of valves and actuators.

B. All software development shall be completed by BAS programmers that have been factory trained in programming and graphic development techniques of the BAS. This includes development of the existing campus BAS operators' software, if it differs from the manufacturer of BAS equipment supplied on this project. All software developed shall be programmed to integrate seamlessly with the existing network of similar installations of this same BAS at LANL which reside on one of the existing LANL BAS servers. In other words, new buildings shall be hung on existing trees.

3.2 NETWORKING/COMMUNICATION

A. General

1. All LAN's shall be installed in a manner recommended by the manufacturer, based on the environment, communications speed requirements, and distance. All LAN media shall be installed in a manner that provides protection from physical damage and interference from RF or other electrical sources.

B. Primary Local Area Network (LAN)

1. The Primary LAN is existing; however, all media required to connect new Gateway Controllers to the Primary LAN shall be installed with materials and procedures that comply with the requirements of the facility communications personnel and the BAS equipment manufacturer. The necessary IP addresses for the GWC's shall be assigned by LANL CCN-5 in coordination with LANL FWO-DECS.

C. Controller Local Area Network (LAN)

1. The Controller LAN shall be installed with materials and procedures that comply with the requirements of the BAS equipment manufacturer. In general, the conductors are to be a 22 gauge, low capacitance, twisted-pair.

D. Sub-Controller Local Area Network (LAN)

1. The Sub-Controller LAN shall be installed with materials and procedures that comply with the requirements of the BAS equipment manufacturer. In general, the conductors are to be a 22 gauge, low capacitance, twisted-pair.

3.3 BACNET™ COMPATIBILITY

A. All BAS software shall be developed to meet the BACnet™ conformance class of the relevant LAN. Refer to Part 2 of this section.

3.4 BAS SERVERS

A. All new LANL BAS servers shall be located in a lockable server room supplied by a UPS for backup power. The Contractor shall coordinate with FWO-DECS to utilize existing BAS servers whenever possible. Access shall be in coordination with the BAS administrator, usually LANL FWO-DECS. BAS operating software

and all support software shall be installed and configured on the appropriate server. All of the software development specified in this section shall be implemented on all new or existing servers as appropriate for this project.

B. User Access

1. Complete installation of Contract Administrator supplied operator names derived from the approved submittal request form. During the training session, complete the input of login and passwords associated with those personnel.

C. Reports and Trends

1. All associated I/O data as well as computational data shall be linked to the appropriate formatted report for automatic archiving on the LANL BAS server. .

2. Provide report capability for monitoring of each system. Custom reports and trends shall be easily configured by the operator for either printing or archiving. The operator shall be able to easily adjust the scale of the trend graphs and trend at least 3 separate points of the same type (analog with analog, binary with binary) on the same graph as he/she chooses. The trend graphics shall have a dynamic cursor option for identifying values of individual points on the trend graph.

D. Dynamic Color Graphic Displays

1. The slides shall include a color graphic representation of the geographic area or system being observed, all realtime point value data, user interactive setpoints, schedules, etc., and realtime alarm information. Graphics shall provide flexible “pick” options, such as expandable trees, to easily move across the system without the need to go back to the trees start. The focus on the graphic generation shall be ease of understanding and user interaction for all day-to-day functions. At a minimum, the following graphic slides shall be developed:

   a. A graphic shall be provided for each floor and/or quadrant (depending on the size of the building) of each building. All major walls, temperature zones and actual space numbering shall be indicated. These drawings may be scanned from building floor plans or imported from ACAD drawing files and modified as necessary. All zone temperature shall either be displayed within the appropriate zone in text format or the area of each zone shall be color coded to represent the relationship to set point. Each graphic shall indicate the current occupied/unoccupied status of the “building” floor or quadrant group” or “floor subgroup” schedules, the minimum and maximum zone temperature on the floor, the run status of all air handling equipment serving the floor, all un-acknowledged alarms, etc. “Pick” windows shall be provide on these graphics to permit the operator to view a specific building air handling unit graphic or a graphic of the fan coil unit or outside air handling unit supplying a particular area. “Picks” shall be provided to move back to the building or the campus.

b. A graphic shall be provided for each temperature zone of each floor. This graphic shall be a graphic representation of the mechanical equipment serving the zone. All real time system information relative to any particular temperature zone and all color-coding of the temperature zone shall be the same as was provided for the floor plan graphics. This graphic shall indicate the current occupancy status and which schedule group has control of the zone. "Pick" windows shall be provide on these graphics to permit the operator to view the specific supporting mechanical system relative to the respective floor plan or to move back to the building floor plan.

c. Separate graphics shall be provided for all mechanical equipment serving the respective building or zone. This includes all air-handling units, central chilled water plant, heating plant, etc. Mechanical system graphics shall be displayed complete with all real time data relevant to the equipment being displayed including temperatures, flow rates, positions, etc. Every controlled or monitored device (all dampers, valves, filter banks with differential pressure, etc) related to the major unit being described on the graphic, shall be shown and labeled on the same graphic. The intent is to show the entire "chilled water system" or "building heating water system", for instance, as a coherent unit with all the necessary information on a single page.

d. All valves or dampers, whether normally open or normally closed, shall be described as 0% when fully closed and 100% when fully opened as seen on the Web based GUI. Three-way control valves shall have a descriptive label on the GUI that clearly indicates the direction of flow when fully opened or closed.

e. A realtime graphic of the BAS system architecture shall be provided. The graphic shall indicate the actual wiring configuration of all Controllers on the network. Realtime information regarding the communication status of all BAS controllers shall be displayed on this graphic. Additionally, any controller that has an alarm condition shall be clearly identified on this graphic. If the size of the network prevents display of the entire network on one page, multiple graphic slides with connectors and "picks" may be employed.

E. Database Save/Restore/Back-Up

1. All new or existing LANL BAS servers shall have an ongoing backup scheme configured and activated with cooperation from FWO-IIM so that all BAS related software and databases are backed up on a schedule. After all BAS Controller software and Graphic slides have been developed, two complete backup sets of this software shall be stored on CD and delivered to the Contract Administrator for archiving. All future warranty work, software patches, upgrades or punchlist resolution relating to BAS software or graphics shall be done on the appropriate LANL BAS server in coordination with the BAS administrator. In the event of server failure, a verified method of restoring the BAS onto the server from backup shall be included in the BAS administrator training with the controls contractor.

F. Alarm Paging

1. Major alarms shall initiate paging and email notification to designated LANL pagers and email utilizing the LANL email/paging system.

3.5 GATEWAY CONTROLLERS

A. New GWCs shall be installed where required to create a new building Controller LAN.

1. All new GWCs shall be installed in accordance with manufacturer's instructions. 120 VAC Power shall be provided to each GWC. If a GWC requires power at a different voltage or at a location other than as shown on the drawings, it shall be the work of this section to provide and install all necessary conduit, wiring, transformers, etc. and make the final connections. All power shall be verified as work of this section prior to powering the controllers.

2. All BAS Controllers shall be installed in a factory enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Communications

1. It shall be work of this section to connect all GWCs to the Primary LAN. It shall also be work of this section to develop the Controller LAN. This work includes installation and troubleshooting of new media.

3.6 PRIMARY BAS CONTROLLERS

A. General

1. New PFCs shall be installed where required or indicated on the drawings; however, in no case shall more than 90% of the maximum attached potential node limitations be designed nor shall more than 75% of the PFC RAM be utilized by the programming code specified herein, including trending and global programming. If these limits are met, additional PFCs or RAM shall be added.

2. All PFCs shall be installed in accordance with manufacturer's instructions, and 120 VAC power shall be provided to each. If a PFC requires power at a different voltage or at a location other than as shown on the drawings, it shall be the work of this section to provide and install all necessary conduit, wiring, transformers, etc. and make the final connections. All power shall be verified as work of this section prior to powering the controllers.

3. All PFCs shall be installed in a factory enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Communications

1. It shall be work of this section to develop Controller LAN. This work includes installation and troubleshooting of new media. All PFCs shall be connected to the Controller LAN network in a manner recommended by the manufacturer based on the environment, communications speed requirements, and distance.

C. Input/Output

1. The installation of all BAS field control components and the associated I/O wiring back to the respective BAS Controller shall be installed under this section of the specification. Each point shall be checked by the contractor for voltage, short circuit, etc. prior to termination to the PFC to prevent potential damage to the controller.

D. Software Requirements

1. All sequences of operation as stated in the Contract Documents are to be implemented. In addition to these specific sequences, the following general requirements shall be implemented to for a complete operating software package.

    a. SOO Features: The following features shall be provided as a minimum:
        - Unoccupied operations
        - Optimal start
        - Supply air reset based on zone load
        - Boiler operation based on zone demand
        - Chiller operation based on zone demand
        - Heating and chilled water temperature reset based on zone demand

    b. Run Time Totalization: All digital input, digital output points, and digital software points (triggers or flags) shall be setup to accumulate totalized run time information. The frequency of accumulation and reset shall be based on report and trending requirements.

    c. Alarms:

        i. The following analog input points shall have upper and lower limits established and alarms shall be generated in the event these limits are exceeded. These limits are generally defined as follows:

ALARM PARAMETER TABLE			
Point Type	Low Condition	High Condition	Reset Condition
Space Temperatures	5.0°F < active SP	5.0°F > active SP	2.0°F change
Supply Air Temperatures	5.0°F < SP	5.0°F > SP	2.0°F change
Outside Air Volume	<95% of SP	> 110% SP	5% change
CWS Temperature	2.0°F < SP	3.0°F > SP	1.0°F change
HW Temperature	2.0°F < SP	3.0°F > SP	1.0°F change
Duct Static	<90% of SP	> 110% SP	5% change
Velocity Pressure (Flow)	<90% of SP	> 110% SP	5% change
Static Pressure Space	<90% of SP	> 110% SP	5% change
Humidity	<90% of SP	> 110% SP	5% change

ii. Digital inputs shall be compared to the associated digital outputs (e.g., fan start/stop vs. fan status) and alarms shall be issued if the commanded position is inconsistent with the actual condition, after a start delay timer of 30 seconds.

iii. All digital points that represent actual alarm monitoring points (e.g., VFD alarm) shall display an alarm immediately upon indication of an alarm condition.

iv. All alarms shall be viewable via the Web based GUI, and archived on the hard drive as routed by the user. The identity of the operator acknowledging the alarm shall be archived with the alarm message text.

d. Minimum Runtimes: All digital output points shall have a minimum runtime of 5 minutes to prevent accidental short cycling.

e. Staggered Starts: All digital outputs to motors or equipment with input voltages of 480 VAC or more within a particular building shall have staggered start times of 15 seconds to minimize demand spikes, especially after a power failure restart.

f. Trend Analysis: The system shall be configured to trend all system points and display them both numerically and graphically. Date and time stamps shall accompany all trend data. The initial interval for all trend logs shall be configured for 15 minutes or change of value (COV) as reason dictates. Trend groups shall be identified as follows:

OUTSIDE AIR UNIT TREND LOG GROUPS (Typical of all units)	
Sub-System Function	Group I/O & Software Points to Trend
Fan Operations (Digital)	Occupied/Unoccupied Mode, Optimal Start Mode, Override Mode, Temp. Override Mode, VFD Alarm, VFD Start/Stop
Supply Air (Typical)	Supply Air SP, Supply Air Temp, Chilled Water Valve Position

3.7 APPLICATION SPECIFIC CONTROLLERS (ASC)

A. The same execution requirements specified for the Primary BAS Controllers shall apply to the Application Specific Controllers.

3.8 UNITARY CONTROLLER INTERFACE (UCI)

A. General

1. New UCIs shall be installed where required or indicated on the drawings; however, in no case shall more than 90% of the maximum attached UC node limitations be designed.

2. All UCIs shall be installed in accordance with manufacturer's instructions. 120 VAC power shall be provided to each UCI. If a UCI requires power at a different voltage or at a location other than as shown on the drawings, it shall be the work of this section to provide and install all necessary conduit, wiring, transformers, etc. and make the final connections. All power shall be verified as work of this section prior to powering the controllers.

3. All UCIs shall be installed in a factory enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Communications

1. It shall be work of this section to develop Controller LAN for connection of each UCI. This work includes installation and troubleshooting of new media. All UCIs shall be connected to the Controller LAN in a manner recommended by the manufacturer based on the environment, communications speed requirements, and distance.

C. Alarms

1. The same analog input points described in the Primary BAS Controllers section above shall be used for all UCs connected to the Sub-Controller LAN, with upper and lower limits established and alarms generated in the event these limits are exceeded. The Contractor shall submit specific limit details for every point; however, these limits are generally defined as described in the ALARM PARAMETER TABLE for the Primary BAS Controllers section above.

   a. Digital inputs associated with all attached UCs shall be compared to the associated digital outputs (e.g., fan start/stop vs. fan status) and alarms shall be issued if the commanded position is inconsistent with the actual condition, after a start delay timer of 30 seconds.

   b. All alarms shall be directed viewable via the Web based GUI, and archived on the hard drive as routed by the users. The identity of the operator acknowledging the alarm shall be archived with the alarm message text.

D. Trend Analysis

1. The system shall be configured to trend all UC points and display them both numerically and graphically. Date and time stamps shall accompany all trend data. The initial interval for all trend logs shall be configured for 15 minutes or change of value as reason dictates. Trend groups shall be identified as follows.

2. The following table is provided as an example of the trend log. Provide trend logs for monitoring each system.

VAV TERMINAL UNIT TREND LOG (Typical of all units)	
Sub-System Function	Group I/O & Software Points to Trend
Space Temperature Loop	Space Temp. SP, Space Temperature, Hot Water Valve Position, Primary air flowrate.

3.9 UNITARY CONTROLLER (UC)

A. General

1. A new UC shall be installed for each fan coil unit, VAV unit, unit ventilator, etc. The UC shall mount directly on the equipment unit or nearby. UCs shall be installed such that reasonable access to the unit can be achieved. The installation shall not interfere with access to other components.

2. All UCs shall be installed in accordance with manufacturer's instructions. 120 VAC Power shall be provided at various locations as indicated on the drawings. If a controller requires power at a different voltage or a location other than as shown on the drawings, it shall be the work of this section to provide and install all necessary conduit, wiring, transformers, etc. and make

the final connections. All power shall be verified as work of this section prior to powering the controllers.

3. All UCs shall be installed in a factory enclosure that provides protection from the environment and is adequately ventilated to protect against excessive temperature exposure.

B. Communications

1. It shall be work of this section to install the Sub-Controller LAN from each UCI. This work includes installation and troubleshooting of any new or existing media. All UCs shall be connected to the BAS Sub-Controller LAN in a manner recommended by the manufacturer based on the environment, communications speed requirements, and distance.

C. Input/Output

1. The installation of all BAS field control components and the associated I/O wiring back to the respective UC shall be installed under this section. Each point shall be checked by the contractor for voltage, short circuit, etc. prior to termination to the BAS Controller to prevent potential damage to the controller

3.10 ELECTRONIC TEMPERATURE ELEMENT AND TRANSMITTER

A. All temperature sensors shall be installed and wired under this section of the specification.

1. Immersion temperature sensors shall be installed in the thermowells provided with the sensor. A thermo-conductive paste shall be applied between the sensing element and the thermowell.

2. Outdoor air temperature elements shall be installed in a location that is continuously shaded and not effected by heat generating equipment or equipment intakes or discharges. The element shall be installed under a sun shield and high enough to avoid damage from vandalism.

3. Duct point temperature elements shall be installed directly on ductwork and the connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Care shall be taken to avoid direct contact between the temperature element and any heat transfer surface such as a coil.

4. Duct averaging elements shall be installed with the same requirements as for the temperature point element; however, the averaging element shall be extended across the entire duct area in a zig-zag pattern. Special clips shall be used to secure the element at turns to prevent chafing of the element. Where the element passes through the duct, plastic tubing or similar protection shall be installed on the element to prevent damage to the element from vibration.

5. Space temperature transmitters shall be installed 60” above finished floor. If a setpoint adjustment is provided on the sensor then the unit shall be installed 48” above finished floor (A.F.F.)unless otherwise specified on the plans. Location of space temperature sensors shall be coordinated with furniture layout drawings to avoid dead air space behind bookshelves or discharge heat from equipment (such as printers, copiers, coffee pots, etc.).

6. Space temperature sensors shall be mounted in server and telecommunications rooms for monitoring and alarm in case of CRAC (computer room air conditioner) failure. Temperature sensors shall also be provided in the mechanical equipment rooms for monitoring and alarm. These alarms shall be sent to duty pagers via the BAS.

3.11 CURRENT TRANSDUCERS

A. Current transducers shall be installed on one hot leg of either single or three phase and after the local disconnect. The transducer shall be securely mounted in the associated motor starter housing or motor control.

3.12 CURRENT SENSING SWITCH

A. Current switches shall be installed in one leg of three phase circuits and the hot leg of single phase circuits and in all cases, after the local disconnect. The switch shall be securely mounted in the associated motor starter housing or motor control. The switches shall be adjusted to close at approximately 10% of the attached load’s full load amps.

3.13 AIR DIFFERENTIAL PRESSURE SWITCHES

A. Differential pressure switches shall be connected to pitot tube pickup probes pointing into the air stream on both sides of the process variable. Connection between the switch and the pitot tubes shall be 1/4” hard copper. The switches shall be adjusted to close at approximately 25% of the fans maximum speed.

3.14 ELECTRIC LINE VOLTAGE THERMOSTAT

A. Where thermostats are to be mounted remotely from the controlled device, all Class I and/or Class II conductors shall be installed in a metallic raceway and the thermostat shall be mounted on a junction box. Mount the thermostat 48” A.F.F unless otherwise specified on the plans.

3.15 ELECTRIC FLOW SWITCH

A. Flow switches in liquid lines shall be installed in a Thread-O-Let with isolation valve or valves to allow removal without draining the system. The paddle of the flow switch shall be selected and the spring adjustment shall be carefully set to provide good switching between flow and no flow conditions. Ensure that the flow direction of the device matches the actual flow direction.

3.16 LIQUID DIFFERENTIAL PRESSURE SWITCH

A. Differential pressure switches shall be connected to pressure taps installed on the piping under other sections of the specification. The connections shall be 1/4" hard copper complete with isolation valves on both lines. The switch shall be supported either by mounting on a wall or on a frame constructed from Unistrut. The switch setpoint and differential shall be set as necessary to provide good switching between pressure and no pressure conditions.

3.17 CONTROL RELAYS

A. Control relays shall be mounted in the respective termination panel and are intended primarily to isolate the BAS controller digital outputs from the source load. If a relay must be field mounted, it shall be installed in a NEMA I housing.

B. Control relays shall be installed in bases and the based mounted on a DIN rail. All accessories including end clips, jumpers, etc. shall be provided. All wiring shall be labeled. Multiple conductors shall be bundled and run by Class in plastic wireways. Relays shall be labeled as indicated in the shop drawings for ease in troubleshooting.

C. Relays coils shall be wired complete with 24 VAC power such that a jumper (simulating an BAS contact closure) will energize the control relay.

3.18 CONTROL TRANSFORMERS

A. Control transformers shall be field mounted using a plate to mount on an electrical junction box. Locations shall be as identified on the shop drawings or as determined by field requirements.

B. A phenolic label on each transformer shall identify the power source by breaker panel and circuit. Fusing of the primary and secondary sides and sizing shall be as required by the NEC.

3.19 AUTOMATIC DAMPERS

A. All automatic control dampers shall be installed under this Section.

3.20 DAMPER ACTUATORS

A. Electronic Damper Actuators

1. Damper actuators shall be mounted on the damper jackshaft or shaft extender using a "V" clamp. The actuator shall then be anchored to the ductwork housing the damper.

3.21 CONTROL VALVES

A. The valves will be installed by the mechanical contractor and are outside the scope of this section.

3.22 CONTROL VALVE ACTUATORS

A. Electronic Valve Actuators

1. Valve actuators shall be mounted in either the vertical (above the pipe) or 90 degrees from vertical position. Steam valve actuators shall be mounted at 90 degrees from vertical to avoid heat damage to actuator. Actuators shall be installed to ensure they do not interfere with the operation or access to other equipment such as balancing valves. Actuators shall be configured in a consistent manner with attention to actuator rotation direction so that a 0% "close" or 100% "open" command has consistent results to close or open the valve. All valves serving coils exposed to outside air and possible freezing conditions shall be tested and documented to proper rotational direction.

3.23 INPUT/OUTPUT AND INTERLOCK WIRING

A. General

1. All wiring located in mechanical spaces, chiller or boiler plants, outdoors, in exposed areas, or in areas of potential damage, regardless of class, shall be run a metallic raceway of the appropriate design for the application. Refer to Division 16.

2. All Class I and Class II conductors shall be selected and installed in complete compliance with the NEC, regardless of the definition of conductor types stated for each device type. The conductor types stated for each device type installation are provided to indicate the design intent only.

B. Class I Wiring

1. All wiring shall be installed in accordance with the NEC and Division 16. Class I and Class II wiring shall be separated as defined in Art. 725 of the NEC. All Class I circuits and all control or power circuits greater than 48 VAC or VDC shall be run in a metallic raceway. Conduit shall be run parallel with building lines in a neat professional manner and supported as defined in Division 16.

C. Class II Wiring

1. All wiring shall be installed in accordance with the NEC and Division 16. Class II wiring run in hollow walls and in accessible concealed areas may be run without conduit, as local codes permit. Cables run loose shall be tied to building structures no less than every 6 feet and bundled where possible. Care shall be taken to avoid chafing at points of connection to the building. Cables run in conduit shall be installed in the same manner required for Class I conduit runs.

3.24 REFRIGERANT VAPOR DETECTOR

A. The refrigerant vapor detector shall be installed indoors at a location indicated on the drawings. Mount the unit at height consistent with the manufacturer's instructions that provides for easy maintenance and visual observation.

3.25 INDOOR AIR QUALITY SENSOR

A. The IAQ sensor shall be mounted on the ductwork and in rooms where indicated on the system description. Exercise caution during installation to prevent contamination of the sensor element.

3.26 EQUIPMENT CONNECTIONS

A. BAS Class II field wiring for all non-control device applications shall be installed under this section of the specification. This includes equipment such as VFDs, chillers, boilers, etc. that may have point types include status or alarm monitored from an equipment supplier Class "C" contact or analog control signals to equipment, etc.

3.27 DUCT STATIC PRESSURE STATION

A. Ensure that the direction of flow is observed when installing the probe to prevent measurement of total pressure. The connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Connections from the "HI" pressure port to the differential pressure transducer shall be 1/4" plastic tubing that shall not extend for more than 10 feet.

3.28 DUCT VELOCITY STATION

A. Ensure that the direction of flow is observed when installing the probe and maintain the manufacturer's recommended upstream and downstream distance requirements. The connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage. Connections from the "HI" and "LO" pressure ports to the differential pressure transducer shall be 1/4" plastic tubing that shall not extend for more than 10 feet.

3.29 OUTSIDE AIR STATIC PRESSURE PROBE

A. Outside air static pressure probe shall be installed and piped according to manufacturer's instructions to ensure accuracy of the static pressure reading and eliminate the effects of condensation in the sensing lines, respect to prevailing wind direction and building geometry. Please seek advice from LANL FWO DECS with any questions regarding installation. Coordinate installation of probe with the necessary trades for proper sealing of all roof penetrations.

3.30 ELECTRONIC DIFFERENTIAL PRESSURE TRANSMITTER

A. All differential pressure transmitters shall be installed within 10 feet of the pressure sensing point. The transmitters shall be installed in a NEMA I housing

for interior conditioned spaces and in NEMA 3R housings for outside or unconditioned spaces. The transmitters and housings shall be rigidly supported to prevent vibration and shall never be mounted to ductwork or piping. Access to the transmitter shall be provided.

3.31 ELECTRONIC AIR FLOW ELEMENT AND TRANSMITTER

A. Ensure that the direction of flow is observed when installing the probe and maintain the manufacturer's recommended upstream and downstream distance requirements. The connection between the duct and the flange shall be gasketed and secured with sheet metal screws to prevent any air leakage.

3.32 ELECTRONIC LIQUID FLOWMETER

A. The flow meter/ transmitter shall be installed according to the manufacturer's recommendations with isolation valve or valves to allow removal without draining the system and tied into the DDC system.

3.33 ELECTRIC LOW LIMIT (FREEZESTAT)

A. Low limit thermostats shall be installed with the averaging element extended across the entire duct area in a zig-zag pattern. Special clips shall be used to secure the element at turns to prevent chafing of the element. Where the element pass through the duct, plastic tubing or similar protection shall be installed on the element to prevent damage to the element from vibration. The thermostat setpoint shall be set as indicated and the circuit shall be tested to ensure actions as required.

3.34 SMOKE AND FIRE DETECTORS

A. Installation of smoke detectors and the associated wiring are outside the scope of this Section (ref Section 28 3100, Fire Detection and Alarm); however, under this section, provide an interlock for HVAC shutdown from the fire detection system.

3.35 COMMISSIONING

A. Refer to Section 23 0800, Commissioning of HVAC and Section 01 9100, Commissioning.

END OF SECTION

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Do not delete the following reference information:

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FOR LANL ONLY

This project specification is based on LANL Master Specification 25 5000 Rev. 0, January 6, 2006.